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# Visual-Thinking in Congenitally Blind Individuals

*Abstract: What is mental imagery like for the congenitally blind? Using a combined storytelling and clay modelling task and an analysis of the clay models in terms of a physical ontological concept, we observed the visual-like abstraction of congenitally blind individuals. Next, we observed their distinct mental lexicon construction through an analysis of how they include attributive adjectives of an animal's savageness using semantic memory. The results demonstrated that visual thinking is a conflict between immature visual cognitive resource with critical adult logic induced by the absence of visual recognition and the proper resources for a mental lexicon. This leads to feelings of estrangement, which allows this ambiguous concept to occur. To capture visual phenomena, their brain harnesses another particular mode of thinking, associative and/or bisociative thinking, as a referral in addition to employing self-body referencing as an archetype. We discuss how these findings can be applied to possible employment opportunities for people with visual impairments.*

*Keywords: Visual Thinking, Congenitally Blind, Creativity, Bisociative Thinking, Clay Modeling*

## Introduction

It has long been observed that the absence of vision appears to enhance processing by the remaining senses (James 1950). However, divergent results have been reported in studies investigating spatial cognition (Proulx et al. 2016; Pasqualotto et al. 2018). How does the blind brain support such superior processing? There is substantial evidence that the brain uses the visual cortex to support behavioral enhancements (Pasqualotto and Proulx 2012). Many empirical studies have reported results supporting this view, showing that blind persons can have superior perceptual discrimination and localization, verbal processing, and memory capacity, as noted in a recent review by Pasqualotto and Proulx (2012). Blindness enhances the sensory modalities (Scheller, Petrini, and Proulx 2019; Fielder and Proulx 2019). Compensatory plasticity enhances the auditory (hearing), somatic sensation (touch), gustatory (taste), olfaction (smell) and vestibular (balance/movement) senses. Thus, the realm of the mind where blind people interpret information and create perception can be extraordinarily distinct from sighted people (Dell'Erba, Brown, and Proulx 2018).

### *Mental Imagery of Congenitally Blind Individuals*

Most of the research concerning visual imagery focus on activation in primary visual areas by means quantitative and technological devices for analyzing. Kosslyn et al. (1999) uses convergent techniques: PET and repetitive transcranial magnetic stimulation (rTMS), Farah et.al. (1988) measured event-related electrical potentials in the brain using ERP, D'Esposito et.al. (1997) investigated neural substrates of mental image generation with functional MRI (fMRI), and Knauff et al. (2000) also conducted an experiment with fMRI. Lopes (2003) studies visual activation in dreams and its relationship with EEG's spectral components.

Most of these studies, though, have investigated the underlying mechanisms of visual imagery with quantitative approaches that have paid less attention to activity itself. Moreover, most of this work has focused on the sighted only. A few studies have reported that congenitally blind (CB) individuals, who have never experienced sight, are able to visualize and have capacity for visual imagery with slight or no differences when compared with normal sighted subjects (Bértolo 2003). Yet mental imagery in CB individuals is uniquely different to sighted people (Cattaneo and Vecchi 2011). CB individuals create specific pattern that allows object to be recognized as unique without retinal inputs as seeing with the "mind's eye" based only in the preservation of metric and spatial properties (Bértolo 2005). The ability to perceive and extract surrounding information relies on the remaining intact senses and common sense. However, the absence of visual experience certainly prevents CB individuals from accessing pattern recognition or principles of organization. To capture the visualizable phenomena, the brain harnesses another particular mode of thinking—associative and/or bisociative thinking—as a referral by way of traditional Aristotelian categorization and Rosch's prototype theory (Koestler 1976a; Rosch 1975; Homa et al. 2009).

Koestler (1976b) coined the term "bisociation" to describe the combinatorial nature of a creativity event. Bisociation requires two incompatible concepts, which are not normally associated, to create a collision of two concepts or events producing an ambiguous correlation. Cartoon editor Bob Mankoff describes it as "a conflict of synergies" (Popova 2013). It is a surprising or amusing event in which one finds enjoyment in a paradox. The event of tactile sensation in experiencing a live fish and a fried fish would lead to a collision of concept. In addition, this collision of concept might be more mixed up when self-referencing their physicality as humans. Bisociative thinking is the mixture of two or more concepts that are considered separate by the mind, and thus could be a potential mechanism for creativity. Koestler (1976a; 1976b), Finke (1988), Fauconnier (2001), and Nagai et al. (2009) studied bisociative thinking, which has much potential in the abstraction process. The bisociative way of thinking is unconscious and no reliant on visual experience, and thus is attainable with ease by CB individuals.

This type of cognitive skill allows them to detach from familiarization. This is supported robustly by our previous study to modify creative skill enhancement for people with traditional viewpoints (Junaidy and Nagai 2012, 2013). Thus, the realm of the mind where blind people interpret information and perceive can be extraordinarily distinct from people with normal vision. Campbell (1960), Simonton (2013), Cattaneo and Vecchi (2011), Shinohara and Tenenberg (2009) reported that creativity requires blind variation and selective retention. The basis for this in sensory experience might be that the sighted are bound by what they have already seen. The blind may thus have fewer restrictions due to their lack of visual experience. Therefore, there could be a surprising correlation between low levels of creativity with sightedness. For sighted people, being given a set of examples could also be seen as a means of framing the situation and restrict their creativity (Finke and Slayton 1988), we are curious on how CB individuals experience such examples when provided verbally (semantically). On the one hand, mental imagery, apart from familiarization, allows one to yield a broad distance of conceptualization or high-level abstraction. On the other hand, familiarization leads one to think with a narrow distance of conceptualization or low-level abstraction. The broader the concept or associative concept, the more the possibility of accessing unconventional ideas (Mednick 1962). Therefore, involving CB individuals as participants of this project would open a new creative endeavor distinct from our existing knowledge. Our research question is to study CB individuals' visual recognition and their ability to associate and reconstruct a concept that we believe has the potential to access particular mode of thinking like bisociative thinking.

Visual thinking is in conflict between immature visual cognitive resources and critical adult logic. The absence of visual recognition is forced to emerge without the proper resource of the visual-mental lexicon that is useful for abstraction. The immature visual cognitive resource must retrieve some logic required by adult common sense based on experience. In fact, the attempt to connect dissimilarity between two realms brings a vague concept and estrangement that creates an ambiguous concept like "animan" or "manimal."

We studied the mental imagery of CB individuals during a visual-thinking experiment through some particular semantic concepts (e.g., "bird," "wing," and "fly"). Those stimuli might mean something completely different outside of the visual realm. The forms and concepts of "bird," "wing," and "fly" are allegedly unlike those of cognitively conceived by sighted people. A CB person does not have visual references of the concepts of streamlined shapes, aerodynamic shapes, or the mechanical properties of a wing. What is the difference between a bird and a flying saucer? Therefore, "a bird with wings to fly" is possibly visualized as a static or curvy figure with "one" or "some" wings drawn with zigzag lines or continuous lines with a horizontal or even vertical orientation. As CB individuals had greater dissociation memory capacity and fidelity for recalling and reduce false memories for the lure (Pasqualotto 2013). Their ability in dissociation might lead to an ability to bisociative thinking, making them less reliant on prior experience restricting them to some sort of realistic prototype (Homa et al. 2009). This dissociation and bisociation might be resourceful for an unconventional idea that will potentially be developed for creative products.

## Method

To investigate the potential visual-thinking ability of CB individuals, we studied distinct mental imagery of CB individuals during an activity of clay modeling (during the clay-modeling, the participant also told the facilitator the object he or she was making). We observed the visual abstraction of CB individuals as they imagined an common animal (a group of entity related with a hierarchy and the category, for example, A: Animal; B: Bodily; C: Capability; D: Domain e.g., $A^1$, $B^1$, $C^1$, $D^1$ => "A winged bird flying in the air" (this is ontology is demonstrated as Example a in Table 1).

Table 1: Physical Ontological Concept of an Animal

| | *A: Animal* | *B: Bodily* | *C: Capability* | *D: Domain* |
|---|---|---|---|---|
| *Example a* | [$A^1$ = bird] | [$B^1$ = wing] | [$C^1$ = fly] | [$D^1$ = air] |
| *Example b* | [$A^2$ = cat/snake] | [$B^2$ = foot/footless] | [$C^2$ = walk/crawl] | [$D^2$ = land] |
| *Example c* | [$A^3$ = fish] | [$B^3$ = fin] | [$C^3$ = swim] | [$D^3$ = water] |

*Source: Data Adapted from Junaidy (2016)*

We suspect there can be cross-selection between concepts characterized by their visual-thinking ability in combinations that indicate bisociative thinking (i.e., $A^2$, $B^1$, $C^3$, $D^1$ => "A winged *snake* swimming in the sky").

### *Participants*

Our study participants were ten congenitally blind students from the School for the Blind in Wyata Guna, Indonesia (7 males and 3 females) aged 17-33 (mean age 20). The participants were congenitally blind high school students enrolled at a Wyata Guna, one of the biggest schools for the blind in Indonesia. The school is mostly comprised of students who reside on campus, but it also accepts day students. The students mainly come from East Java. They are also given life skills training such as massaging, computer skills, and other lines of work. The ten participants have been blind since birth due to congenital and familial optic nerve and retinal problems. Participants comes from middle to low class family, where they family entrusted the school to give appropriate education and serves elementary, middle and high school students every year at an average of 100 students. Informed consent was obtained from all participants. Study approval was provided by the officials of the School for the Blind in Wyata Guna, Indonesia. None of the participants have sensory or cognitive problems. The five facilitators were teachers and research assistants from the same school.

### *Procedure*

We conducted a storytelling experiment with a clay modeling activity. A facilitator accompanied each participant who was asked to discuss and confirm what they were doing with the clay. The five facilitators sat close to each participant, participated in the discussion, and took extensive notes throughout the entire clay modeling process to confirm the following:

- Physical attributes of the selected animal.
- Physical mechanisms of attributes of the selected animal.
- Characteristics of the selected animal.

*The steps were as follows:*
<u>Experiment 1. Storytelling of a chicken</u>
Five participants (Group A) were asked to make a clay model of a chicken that included a physical ontological concept.
Time: 15 Minutes

<u>Experiment 2. Storytelling of a land/water/air animal</u>
Five participants (Group B) were asked to select an animal and make a clay-model that included the land/water/air animal's physical ontological concept. Note that there were no cases of participants selecting a violent animal for this experiment; if they had, they would have been dissuaded to do so due to the nature of Experiment 3.
Time: 15 Minutes

<u>Experiment 3. Storytelling of a violent land/water/air animal</u>
Five participants (Group B) were asked to select a land/water/air animal and make a clay-model that included the animal's savageness, using their mental lexicon of semantic memory.
Time: 15 Minutes

Group A and Group B were comprised of different people. Group A was for initial observation only. Storytelling by CB individuals applies an open-ended storytelling Experiment 1 by selecting one animal without concern of its domain (land/water/air animal) and its characteristic (tame or violent type) for clay-modelling and a story explanation. Experiment 1 was intended to allow familiarization of the clay material use. A closed-ended storytelling experiment was applied during Experiment 2 & 3 with constraints of its domain and its characteristics. Mainly, the evaluation in this study of creative visual thinking is based on the theory of associative basis of the creative process (Mednick 1962). We evaluate their ideas during the clay modeling and its story whether containing more associative concepts that indicate more possibility of accessing unconventional ideas (Junaidy and Nagai 2013). Each facilitator reports this process and take note of the appearance of ambiguous concept that leads to dissociation or bisociative thinking (i.e., "A winged SNAKE swimming in the sky").

Experiment 1 was conducted as a pre-condition to ascertain the level and standard of the participants' cognition of familiar animals, while experiments 2 and 3 provided the main data that we analyzed. Experiment 2 illustrated participants' visual-thinking abilities concerning physical ontological concepts. Experiment 3 showed their ability to escape from mental familiarization towards semantic memory of attributive adjectives of the violent land/water/air animal. Such study by Likova (2012) on learning to draw in the blind, and on the corresponding dynamics of brain reorganization that explain effectively teaching blind adults on a short time-scale, it allows the natural dissociation of cross-modal processing subsystems. Therefore, it is possible that CB individual is able to detach subconscious traditional understanding of the morphological consequences between animals and their attributes of savageness (composition, function, mechanism, interaction, communication) as a form of dissociation; this can also be seen in a case study of a blind artist (Amedi et al. 2008).

We employed Taura and Nagai's design insight and design outsight theory (2009) to analyze the visual abstraction of semantic memory of tame animals and violent animals. We focused mainly on insight, which represents the manner of conceiving the artefactual experience in self-reference/*Autopoiesis* (a term originally coined by Humberto Maturana). Creative mental imagery is indicated by the distance in conceptual space (Gärdenfors 2004). The more creative a concept, the more distant the relationship between the concept and the association that is produced. A narrow concept distance occurs when someone relates the concept of an "ape" with "banana," "woods," etc. A broader concept distance of an "ape" leads to "human" and "intelligent." It reminds us of the concept that follows Koestler's bisociation, which requires two incompatible concepts that are not normally associated to synergize and be accepted.

## Results: Analysis of Visual-Thinking in Congenitally Blind Individuals

Creative mental imagery is indicated by the distance conceptual space (Gärdenfors 2004). The more creative a concept, the more distant the relationship between the concept and the association that is produced. A narrow concept distance occurs when someone relates the concept of an "ape" with "banana," "woods," etc. A broader concept distance of an "ape" leads to "human" and "intelligent." The complete absence of vision from birth causes the ability of object recognition through mental lexicon to be lost. Thus, the observation towards their approach on distinctive memory semantics can be seen through the self-body referencing they perform. The main references in confirming uncertainty in determining shape, dimension, body mechanism (limb), and visual character leads to three sources, namely:

a. Shapes and dimensions refer to the self-body referencing (human).
b. Mechanisms and gestures refer to self-body referencing (human) and familiar animals (i.e., cats, chickens, fish).
c. The visual character and attitudes (i.e., tame or savage) refer to self-body and self-gesture referencing (human) and familiar animals (i.e., cats, chickens, fish), including daily activities such as eating and food to confirm contradictory character differences (a negation between good versus evil).

Figure 1: Storytelling Experiment of Clay Modeling by Congenitally Blind (CB) Individuals to Seek Potential Visual-Thinking Through Observation on Their Mental Lexicon of Semantic Memory.
*Source: Junaidy (2016)*

*The steps were as follows:*

Experiment 1. Storytelling of a chicken

We asked participants to imagine and make a clay model in the shape of chicken. During the process of making the clay model, they verbalized their thoughts and described the chicken. We determined that this process of imagining and visualizing a concept of chicken into 3D clay modeling and verbalizing their thoughts is a process of storytelling  During this experiment we found that instead of experiencing ordinary storytelling of  A,$^{1}$ B,$^{1}$ C,$^{1}$ D$^{1}$ => “A winged chicken walking on the ground,” participants tend to access multiple unusual storytelling (see Table 1). Eighty percent of the participants demonstrated unusual combinatorial concepts that likely accessed distinct visual abstraction.

The unusual combinatorial occurred from

It was found that eighty percent of the clay models and the storytelling depicts unusual shape and story of a chicken. Some examples of unusual storytelling were structured as follow, A,$^{1,2,..}$ B,$^{1.,2,..}$ C,$^{1}$ D$^{1}$: “A horned chicken running on the land,” “A long-body, long-hand, long-legged chicken walking on the land,” “A human-legged chicken walking on the land,” and “A human-shaped chicken walking on the land.”  This showed that A: Animal; B: Bodily; C: Capability; D: Domain [A$^{1}$ = chicken/A$^{2}$ = human/A$^{3}$ = worm/snake-like,…] => [[B$^{1}$ = long-legged/B$^{2}$ = horned] + [C$^{2}$ = walking] + [D$^{3}$ = land]] A$^{1,2,..}$, B$^{1.,2,..}$, C$^{1,}$, D$^{1}$ (see Figure 2).

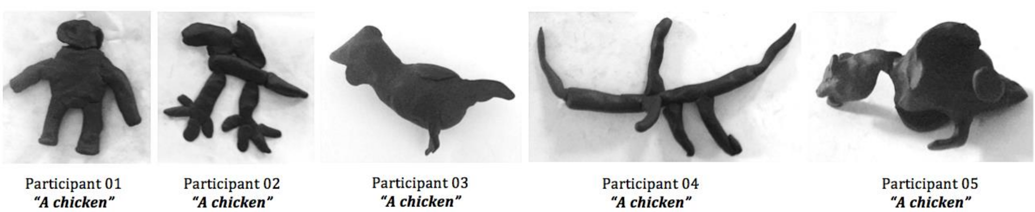



Figure 2: Result of Experiment 1. Storytelling of a Chicken
*Source: Junaidy (2016)*

Experiment 2. Storytelling experiment of a land/water/air animal

In the storytelling Experiment 2, five participants were free to model a land/water/air animal. Three participants selected land animals (cat, giraffe, and duck) and two participants selected water animals (fish and eel). The experiment was observed by facilitators who confirmed the participants’ verbal explanation of their clay models. For example, a giraffe is imagined through their experience of visiting a zoo and receiving an explanation without particular tactile experience. One participant selected an eel because the participant had experience of holding it. Fish was quite familiar to the participants, where they had experienced directly touching the fish cooked and served at meals. A cat was selected because the participant considered a cat very familiar to him and easy to imagine. Direct experience may lead to more precise identification of animal shapes; however, it may also mislead because complete information is not always provided. For example, a fried fish or chicken provides misinformation or a highly distorted example of what that animal looks like (Homa et al. 2008). This seeming lack of information is not necessarily a bad thing, as it could result in the potential for divergent thinking.

Bisociation is shown by matching up some parts of the human body and mechanical movement to these clay animal models. Although each participant successfully imagined a land animal or water animal as their nature, with the correct number of properties, in contrast, the shape, dimension, gesture, mechanism and mainly visual character referred to human properties. The clay model results were categorized as:

a. Ambiguous concept (because of unfamiliarity and no direct tactile experience) $A^{1,2,\cdots}$, $B^{1,2,\cdots}$, $C^{1,2,\cdots}$, $A^{1,2,\cdots}$: “A human-body-duck with human leg walking on the land,” “A human-head-giraffe with human leg walking on the land.”
b. Explicit concept (because of familiarity and direct tactile experience) $A^{1,2,\cdots}$, $B^{1,2,\cdots}$, $C^{1,2,\cdots}$, $A^{1,2,\cdots}$: “A cat walking on the land,” “A fish swimming in the water,” and “An eel laying down on the land.“

Experiment 3. Storytelling experiment of a “violent“ land/water/air animal

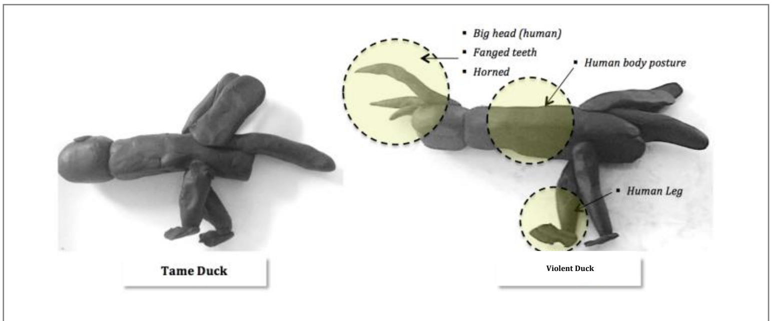
In Experiments 1 and 2, the shape and dimension of the animal clay model referred to self-properties of the CB individual himself/herself. For example, they depicted manifestations of the head, body, hand, and foot that appeared to resemble members of the human body. Mechanisms of motion, gestures, and interactions also tend to display the human motor ability either when moving or reaching out. Other referrals are familiar in animals that interact with them on a daily basis, such as cat, chicken, and fish. The concept of motion, gesture, and interaction of a tame animal is demonstrated with a familiar and ordinary move. As for the concept of ferociousness, the negation was demonstrated with radical, aggressiveness, and savageness. A tame eel and a violent eel are distinguished by a circular-in position and circular-out position.

In terms of the visual character, in which participants are required to visualize savage characteristics of the animal clay model, human figures with imperfect limbs still remain the major reference for depicting the ugliness of savage characteristics. For example, a protruding neck, pug nose, gaping mouth, elongated horn, big eyes, fanged teeth, and long nails describe a conceptual representation of savageness. In addition to humans as a visual reference, the familiar animals around them, e.g., cats or chickens, also become references. Beaks, fangs, claws on chickens and cats were perceived as aggressive concepts.

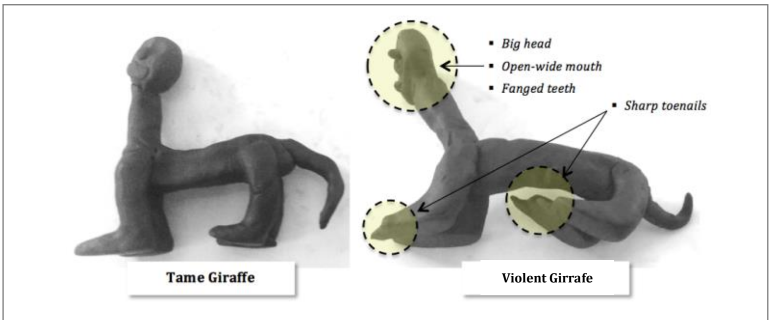
Allegedly, the incompetence of using a linear mode of thinking, referred as associative thinking allows for bisociative thinking occurring as an unintentional mixture of two concepts that are normally considered separate by the literal processes of the mind, for example, a sitting chicken or a horned duck. The violent duck was visualized with a human-like head, body, and legs. For example:

- The angry-looking duck equipped with a horn and fangs. The violent giraffe likely applied a human-like head, body, and legs that included the gesture.
- A big mouth, wide-open, with a bigger head, and some sharp, long toenails characterized the giraffe.
- The shape and the characteristics of the giraffe were found to be similar to the violent cat but without a horn.
- For the water animal clay model, the violent fish was visualized with a big head and body, open extra-wide mouth, and fanged teeth.
- The violent eel was displayed with a big and thick body.

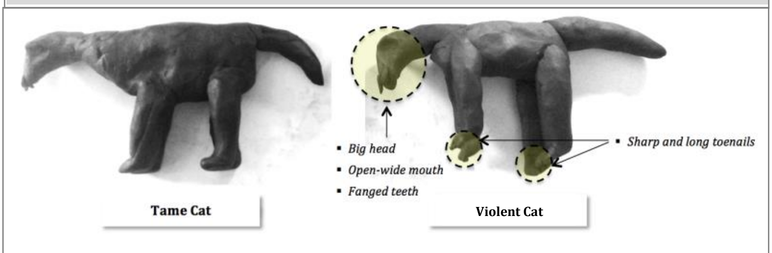
Savage characteristics refers to the representation of a badly-characterized human with a caricature-like, angry face, wide open mouth, and thick lips, with a unique arrangement of the circled-out position to represent violence and a circled-in position to represent a tame eel. Overall, the vague shape is a result of unfamiliarity and no direct tactile experience; the clay models were being coded as $A^{1}$,$^{2}$,.., $B^{1}$.,$^{2}$,.., C1,, $D^{1}$ (See, Figure 3).



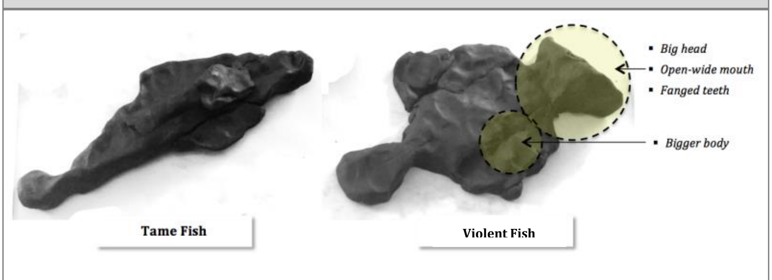

*Participant 6 on Experiment 2 & 3 "Tame Duck and Violent Duck"*



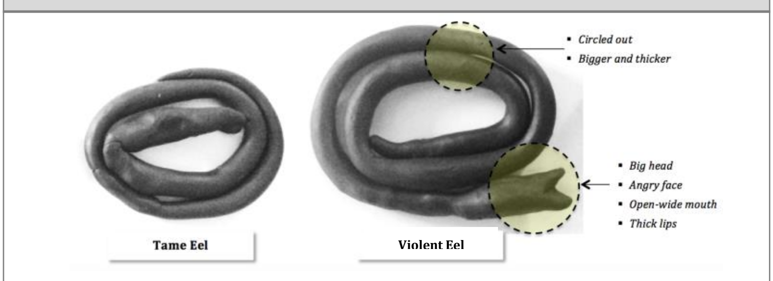

*Participant 7 on Experiment 2 & 3 "Tame Giraffe and Violent Giraffe"*




*Participant 8 on Experiment 2 & 3 "Tame Cat and Violent Cat"*




*Participant 9 on Experiment 2 & 3 "Tame Fish and Violent Fish"*




*Participant 9 on Experiment 2 & 3 "Tame Eel and Violent Eel"*

Figure 3: Storytelling Experiment by Congenitally Blind (CB) Individuals Using Clay Modeling through Given Stimulus: "Tame" & "Violent" Land/Water/Air Animals
*Source: Junaidy (2016)*

We analyzed that common visual abstraction that occurred was structured as follows:
A: Animal; B: Bodily; C: Capability; D: Domain
$[A^1 = \text{bird}] \Rightarrow [[B^1 = \text{wing}] + [C^1 = \text{fly}] + [D^1 = \text{air}]]$ or
$[A^2 = \text{cat/snake}] \Rightarrow [[B^2 = \text{foot/footless}] + [C^2 = \text{walk/crawl}] + [D^2 = \text{land}]]$ or

[$A^3$ = fish] => [[$B^3$ = fin] + [$C^3$ = swim] + [$D^3$ = water]]

A normal derivative structure would be more like:

**$A^1$, $B^1$, $C^1$, $D^1$ => "A winged bird flying in the air**"

**$A^2$, $B^2$, $C^2$, $D^2$ => "A footless snake crawling on the land**,

**$A^3$, $B^3$, $C^3$, $D^3$ => "A finned fish swimming in the water"**

Thus, it could be concluded that a narrow distance between concept yield of a mere conventional concept that evokes no surprise. **This type of abstraction implies no distinct perceptual discrimination.**

We analyzed that distinct visual abstraction that occurred was structured as follows:

**A: Animal; B: Bodily; C: Capability; D: Domain**

[$A^1$ = BIRD] => [[$B^3$ = fin] + [$C^2$ = crawl] + [$D^3$ = water]] or

[$A^2$ = CAT/SNAKE] => [[B1 = wing] + [$C^3$ = swim] + [$D^1$ = air]] or

[$A^3$ = FISH] => [[$B^2$ = foot/footless] + [$C^1$ = fly] + [$D^2$ = land]]

Its derivative structure will be more like:

**$A^1$, $B^3$, $C^2$, $D^3$ => "A finned BIRD crawling in the water**"

**$A^2$, $B^1$, $C^3$, $D^1$ => "A winged SNAKE swimming in the sky**,

**$A^3$, $B^2$, $C^1$, $D^2$ => "A Footed FISH flying on the land"**

A remote distance between concepts potentially obtains unconventional concepts that evoke surprise. Our hypothesis is that a CB individual with no prior visual experience is apt to more imaginative storytelling. This type of abstraction implies *a distinct perceptual discrimination.*

## Discussion of Bisociative Thinking: "Animan*"* or "Manimal*"*

When confronted with the concept of an animal, CB individuals refer to these as properties in relation to themselves. It is not merely the process of transferring the concept of the shape from human limbs to animals (property mapping). This process is a unique mental imagery that is resourceful for bisociative thinking. The examples are ambiguous concept of wings and hand shapes; the vague concept of animal and human motion; the vague morphological visual concept between animals and humans. This distinct bisociative knowledge discovery gives birth to an ambiguous concept such as "crawling chicken" or "sitting chicken." The concept of "crawling," sitting," and "chicken" are stem from the CB's prior knowledge of him/herself as being human. The stem produces mental imagery that loosens our prior knowledge about hierarchical relations of family resemblance (see, figure 4).

In this observation, we found that CB individuals, where they have no visual experience, will seek referral through the physical nature of their existence and other familiar living beings. This is because individuals without visual experiences from birth will likely rely on two major sources only; namely, procedural memory (memory for how to do things) and episodic memory (memory for specific events). One of the most important resources from long-term memory is semantic memory (having to do with words and meaning), which is very less acquired by CB individuals (Pasqualotto 2013).

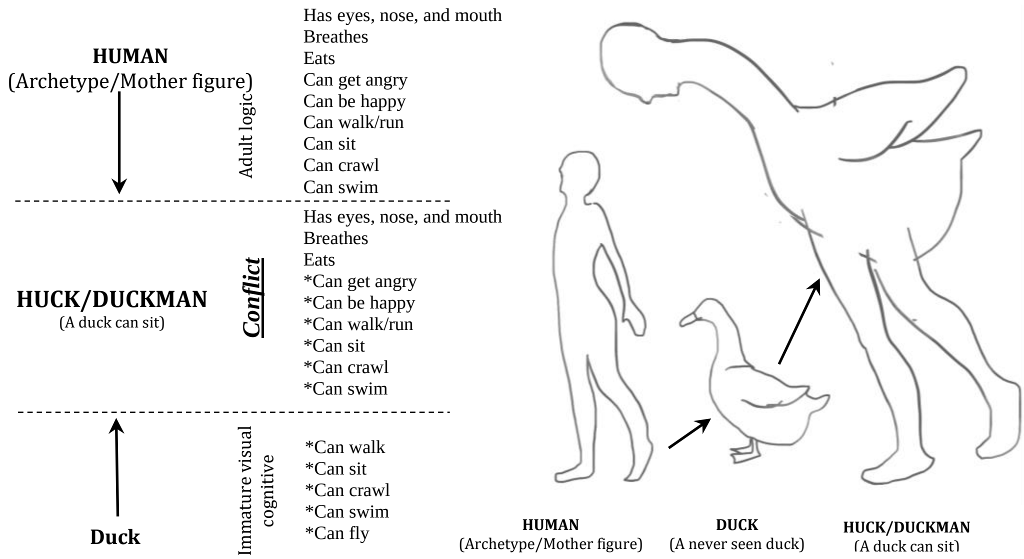



Figure 4: A Hierarchical Network Model of Ambiguous Mental Imagery of Storytelling with Clay Modeling by CB Individuals (author). Distinct Bisociative Knowledge Discovery Gives Birth to an Ambiguous Concept such as "Crawling Duck" or "Sitting Duck." The Concept of "Crawling," Sitting," and "Duck" Stems from Self-Body Referencing that Relies on Him/Her as a Super-Reference.
*Source: Junaidy (2016)*

Another source to enable participants to mentally visualize on a daily basis is interaction with the world around them, whether pet animals or plants. The way they observe something demonstrates the nature of perceived learning through haptic experiences, categorization through primitive correspondence representation, and bisociation. In short, as a CB individual has no prior visual experience from the past, the categorization logic is performed through plain correspondence representation of a mental lexicon that is interchangeable (i.e., animal legs, furniture legs, human legs).

Our study demonstrated that a CB individual's visual thinking is in conflict between immature visual cognitive resources and critical adult logic. The absence of visual recognition is forced to emerge without the proper resource of the visual-mental lexicon that is useful for abstraction. The immature visual cognitive resource must retrieve some logic required by adult common sense. CB individuals attempt to connect dissimilar concepts bring feelings of estrangement and surprise at the same time. This distinct bisociative knowledge likely redefines concepts, such as "bird," "wing," and "fly" that might not always be imagined as a concept that correspond to air. This explains CB individuals use his/herself as physical reference to visualize concepts in their mind. This self-body referencing relies on him/her as a super-reference. This defective mental imagery at certain point is useful for abstraction.

## Conclusion

Research involving people with permanent blindness is a challenge. Mental imagery of CB individuals is an internal experience that extremely difficult to understand. Our experiment requires CB individuals to express internal experiences without experience of visual knowledge, which means that we must use a very personal approach. Dialogue through storytelling could help CB participants to think-aloud their visual thoughts. A life without absolute visual presence requires dependence to interpret and construct a concept and logic. However, this particular mental imagery could generate unusual abstraction can be useful for certain creative activities.

Our research is based on an awareness towards equal opportunity and the importance of capacity building for those who are often excluded from full employment in society. At the same time, we realized the untapped potential that is possible to be contributed from CB individuals for their, and our, benefit. Our endeavor on the discovery of unique visual-thinking that belongs to CB individual is promising, giving impact to communities through further research of the model of co-product design development that acknowledges distinct mental imagery processes uniquely possessed by CB individuals. Together with designers, this approach can be implemented widely in the product R&D process in some industries. The creative products that are potentially suitable to be developed in this very approach are toy design, doll design, stationery design, and other conceptual products.

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## REFERENCES

Amedi, Amir, Lotfi B. Merabet, Joan Camprodon, Felix Bermpohl, Sharon Fox, Itamar Ronen, Dae-Shik Kim, and Alvaro Pascual-Leone. 2008. "Neural and Behavioral Correlates of Drawing in an Early Blind Painter: A Case Study." *Brain Research* 1242: 252–62. https://doi.org/10.1016/j.brainres.2008.07.088

Bértolo, Helder. 2005. "Visual Imagery without Visual Perception." *Psicológica* 26 (1).

Bértolo, Helder, Teresa Paiva, Lara Pessoa, Tiago Mestre, Raquel Marques, and Rosa Santos. 2003. "Visual Dream Content, Graphical Representation and EEG Alpha Activity in Congenitally Blind Subjects." *Cognitive Brain Research* 15 (3): 277–84. https://doi.org/10.1016/S0926-6410(02)00199-4

Campbell, Donald T. 1960. "Blind Variation and Selective Retentions in Creative Thought as in Other Knowledge Processes." *Psychological Review* 67 (6): 380–400. https://doi.org/10.1037/h0040373

Cattaneo, Zaira, and Tomaso Vecchi. 2011. *Blind Vision: The Neuroscience of Visual Impairment*. Cambridge, MA: MIT Press. https://doi.org/10.7551/mitpress/9780262015035.001.0001

Collins, Allan M., and M. Ross Quillian. 1969. "Retrieval Time from Semantic Memory." *Journal of Verbal Learning and Verbal Behavior* 8 (2): 240–47. https://doi.org/10.1016/S0022-5371(69)80069-1

Dell'Erba, Sara, Brown, David J., & Proulx, Michael J. (2018). Synaesthetic hallucinations induced by psychedelic drugs in a congenitally blind man. Consciousness and Cognition, 60, 127-132. https://doi.org/10.1016/j.concog. 2018.02.008.

D'Esposito, M, J.A. Detre, G. K. Aguirre, M. Stallcup, D. C. Alsop, L. J. Tippet, and M.J. Farah. 1997. "A Functional MRI Study of Mental Image Generation." *Neuropsychologia* 35 (5): 725–30. https://doi.org/10.1016/S0028-3932(96)00121-2

Farah, Martha J., Franck Péronnet, Marie A. Gonon, and Marie H. Giard. 1988. "Electrophysiological Evidence for a Shared Representational Medium for Visual Images and Visual Percepts." *Journal of Experimental Psychology: General* 117 (3): 248–57. https://doi.org/10.1037/0096-3445.117.3.248

Fauconnier, Gilles. 2001. "Conceptual Blending and Analogy." *The Analogical Mind: Perspectives from Cognitive Science*, 255–86. https://doi.org/10.1177/1029864917712783

Fielder, Jennifer C., & Proulx, Michael J. (2019). Psychological representation of visual impairment: perception and how blind people "see" the world. The Routledge Handbook of Visual Impairment: Social and Cultural Research (John Ravenscroft, ed.). London: Routledge.

Finke, Ronald A., and Karen Slayton. 1988. "Explorations of Creative Visual Synthesis in Mental Imagery." *Memory & Cognition* 16 (3): 252–57. https://doi.org/10.3758/BF03197758

Finke, Ronald A. 1993. "Mental Imagery and Creative Discovery." *Imagery, Creativity, and Discovery - A Cognitive Perspective Advances in Psychology* 98: 255–85. https://doi.org/10.1016/S0166-4115(08)60145-4

Gärdenfors Peter. 2004. *Conceptual Spaces: the Geometry of Thought*. Cambridge, MA: MIT Press. https://doi.org/10.7551/mitpress/2076.001.0001

Homa, Donald, Michael J. Proulx, and Mark Blair. 2008. "The Modulating Influence of Category Size on the Classification of Exception Patterns." *Quarterly Journal of Experimental Psychology* 61 (3): 425–43. https://doi.org/10.1080/17470210701238883

Homa, Donald, Kanav Kahol, Priyamvada Tripathi, Laura Bratton, and Sethuraman Panchanathan. 2009. "Haptic Concepts in the Blind." *Attention, Perception, & Psychophysics* 71 (4): 690–98. https://doi.org/10.3758/APP.71.4.690

James, William. 1950. *The Principles of Psychology*. Dover Publications. https://doi.org/10.1037/10538-000

Junaidy, Deny Willy, and Yukari Nagai. 2013. "The in-Depth Cognitive Levels of Imagination of Artisans and Designers." *Journal of Design Research* 11 (4): 317–35. https://doi.org/10.1504/JDR.2013.057761

Knauff, Markus, Jan Kassubek, Thomas Mulack, and Mark W. Greenlee. 2000. "Cortical Activation Evoked by Visual Mental Imagery as Measured by FMRI." *NeuroReport* 11 (18): 3957–62. https://doi.org/10.1097/00001756-200012180-00011

Koestler, Arthur. 1976. "Bisociation in Creation." In *The Creativity Question*, edited by Albert Rothenberg, 108–13.

Koestler, Arthur. 1976. "Association and Bisociation". In Play: Its role in development and evolution, edited by Jerome Bruner, Alison Jolly, and Kathy Sylva, 643–649.

Kosslyn, S. M., A. Pascual-Leone, O. Felician, S. Camposano, J. P. Keenan, W. L. Thompson, G. Ganis, K. E. Sukel, and N. M. Alpert. 1999. "The Role of Area 17 in Visual Imagery: Convergent Evidence from PET and RTMS." *Science* 284 (5411): https://doi.org/10.1126/science.284.5411.167

Lakoff, George. 1999. Cognitive models and prototype theory. In *Concepts: Core Readings*, edited by Eric Margolis and Stephen Laurence 391–421.

Landau, B. 1984. "Spatial Knowledge in a Young Blind Child." *Cognition* 16 (3): 225–60. https://doi.org/10.1016/0010-0277(84)90029-5

Likova, Lora T. 2012. "Drawing Enhances Cross-Modal Memory Plasticity in the Human Brain: a Case Study in a Totally Blind Adult." *Frontiers in Human Neuroscience* 6. https://doi.org/10.3389/fnhum.2012.00044

Silva, Fernando H. Lopes Da. 2003. "Visual Dreams in the Congenitally Blind?" *Trends in Cognitive Sciences* 7 (8): 328–30. https://doi.org/10.1016/S1364-6613(03)00155-4

Marr, D., and H. K. Nishihara. 1978. "Representation and Recognition of the Spatial Organization of Three-Dimensional Shapes." *Proceedings of the Royal Society of London. Series B. Biological Sciences* 200 (1140): 269–94. https://doi.org/10.1098/rspb.1978.0020

Mednick, Sarnoff. 1962. "The Associative Basis of the Creative Process." *Psychological Review* 69 (3): 220–32. https://doi.org/10.1037/h0048850

Nagai, Yukari, and Deny W. Junaidy. 2013. "Empowering Cognitive Fixedness." *Proceedings of the 9th ACM Conference on Creativity & Cognition,* 291–94. https://doi.org/10.1145/2466627.2466666

Nagai, Yukari, Toshiharu Taura, and Futoshi Mukai. 2009. "Concept Blending and Dissimilarity: Factors for Creative Concept Generation Process." *Design Studies* 30 (6): 648–75. https://doi.org/10.1016/j.destud.2009.05.004

Pasqualotto, Achille, and Michael J. Proulx. 2012. "The Role of Visual Experience for the Neural Basis of Spatial Cognition." *Neuroscience & Biobehavioral Reviews* 36 (4): 1179–87. https://doi.org/10.1016/j.neubiorev.2012.01.008

Pasqualotto, Achille, Jade S.Y. Lam, and Michael J. Proulx. 2013. "Congenital Blindness Improves Semantic and Episodic Memory." *Behavioural Brain Research* 244: 162–65. https://doi.org/ 10.1016/j.bbr.2013.02.005

Pasqualotto, Achille, Furlan, Michele U. A., Proulx, Michael J., & Sereno, Marty I. (2018). Visual loss alters multisensory face maps in humans. Brain Structure & Function, 223, 3731-3738. https://link.springer.com/article/10.1007%2Fs00429-018-1713-2. https://doi.org/10.1007/s00429-018-1713-2

Popova, Maria. 2013. "How Creativity in Humor, Art, and Science Works: Arthur Koestler's Theory of Bisociation." *Brain Pickings*. https://www.brainpickings.org/2013/05/20/arthur-koestler-creativity-bisociation/

Proulx, Michael J., Gwinnutt, James, Dell'Erba, Sara, Levy-Tzedek, Shelly, de Sousa, Alexandra A., & Brown, David J. (2016). Other ways of seeing: from behavior to neural mechanisms in the online "visual" control of action with sensory substitution. Restorative Neurology & Neuroscience, 34, 29-44. https://doi.org/10.3233/RNN-150541

Rosch, Eleanor. 1975. "Cognitive Representations of Semantic Categories". *Journal of Experimental Psychology: General* 104(3): 192. https://doi.org/10.1037/0096-3445.104.3.192

Scheller, Meike, Petrini, Karin, & Proulx, Michael J. (2018). Perception and interactive technology. Stevens Handbook of Experimental Psychology and Cognitive Neuroscience, 4th edition: Volume 2, Sensation, Perception & Attention (John Serences, ed.). New York: Wiley. https://doi.org/10.1002/9781119170174.epcn215

Shinohara, Kristen, and Josh Tenenberg. 2009. "A Blind Persons Interactions with Technology." *Communications of the ACM* 52 (8): 58–66. https://doi.org/10.1145/1536616.1536636

Simonton, Dean Keith. 2013. "Creative Thought as Blind Variation and Selective Retention: Why Creativity Is Inversely Related to Sightedness." *Journal of Theoretical and Philosophical Psychology* 33 (4): 253–66. https://doi.org/10.1037/a0030705

Taura, Toshiharu, and Nagai, Yukari. 2009. "Design Creativity: Integration of Design Insight and Design Outsight." 特集/デザイン学とはなにか? [*What is" What's the Design"?],* 16 (2). https://doi.org/10.11247/jssds.16.2_55

World Health Organization. 2000. "Programme for the Prevention of Blindness and Deafness." *Global Initiative for the Elimination of Avoidable Blindness*. Geneva: World Health Organization. http://www.who.int/iris/handle/10665/63748